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A STUDY ON THE INCREASING RISKS(TRAUMA) RELATED TO AN AMBULANCE FOR A PARAMEDIC AND PATIENT- A REVIEW

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ABSTRACT

This paper is to evaluate the effectiveness of pre-hospital emergency care. The objective of this review is to study how the ambulance's transport time can be reduced. It aims to address the waiting time of the patient before being given care. To overcome traffic, evolving sensors are being used and how it can be used for emergency vehicles will be studied in this paper. The study shows how wireless accelerometers of IoT wireless sensor system is being used to classify vehicles and monitor traffic volume. The aim is also to compare effective ways of loading, in turn reducing the force experienced by a paramedic. This review outlines tasks where paramedic injuries and ongoing research is carried out to reduce stress undergone by a paramedic. This paper also addresses the compartment design of the ambulance and how paramedic is risking themselves while attending a patient. A database literature search of Scopus was conducted using keywords: "Transport time", "Traffic", "Stretcher", "Musculoskeletal disorder", "Ambulance design", "Paramedic safety", "Ergonomics", "Lumbar", "Compartment space", "Injuries", "patient".

KEYWORDS:Compartment Design, Paramedic, Pre-hospital Transport Time & Stretcher Loading

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Original Article

1. INTRODUCTION

In the case of unstable patients, transfer delay to the hospital causes significant complications/in-hospital mortalities [1,2]. In the case of urban areas, traffic plays an important role in an ambulance to transfer a patient to hospital [2,4]. Studies show that in cities at peak timings traffic signals itself delay ambulance [3,5,6]. Not only reaching to the hospital is time-consuming in traffic, but ambulance reaching to the scene (response time) also adds up the delay. The rapid development of smart cities with increasing vehicles on the road is causing an increase in traffic, which requires traffic management systems to improve [5,6,7].

Ambulances paramedics provide pre-hospital emergency care to reduce mortality. None-the-less, they also must load/unload the patient [4,8]. The stretcher is used for loading/ unloading of a patient [9]. A paramedic who is loading a stretcher into an ambulance is associated with high risk of back pain and musculoskeletal disorders [10-13]. A lot of force is applied on paramedic while lifting the stretcher and placing in the ambulance [12,14-15]. Musculoskeletal disorders are standing at second place after stress among paramedics as shown in table 1[10,11,16].

Rear compartment passengers and paramedics are more likely to hurt than the front driver compartment [16-18]. Pre-hospital care involves not only transport of the patient, but also to provide care to the patient. The design compartment plays an important role in pre-hospital responsive care [14,19-20]. Conventional design is in such a way that a paramedic must move around the ambulance for accessing equipment to treat patients and carry out various tasks. Awkward postures caused by stretching to reach and bending for equipment, to reach patients are some additional contributors to risks [4,10]. Moving around in the moving ambulance proves risky causing injuries to paramedic and fatal injuries in some cases [8,18].

Table 1: Data shows the Increasing Percentage of People Affected by Two Major Concerns

Concern	Year 1 (%)	Year 2 (%)
Stress (Psychophysical) [16,23-25]	70	74
Musculoskeletal disorders (Biomechanical) [10,11,16,26-27]	59	62

2. TRANSFER DELAY

Pre-hospital emergency care involves various segments namely: Ambulance service center, traffic management, paramedic care [1-2]. Traffic management is an important part when it comes to transport, though rural areas don't observe much traffic delaying ambulance when it comes to the urban scenario, ambulances are seen standing for too long at signals [28]. Time is of the essence in trauma situations for the survival of patients. Studies have shown a significant number of deaths with trauma patients for not reaching in time. So, to reduce these numbers, the focus has been on to reduce pre-hospital time [1,3,29,30].

2.1 Traffic Management

In Urban areas, as traffic signals are one where delay time rises rapidly; traffic management systems must improve in bias to the easy flow of ambulance. An intelligent traffic management system analyzing traffic at signals by continuous monitoring of emergency vehicles through Wireless Sensor Networks (WSNs) can help reduce waiting time at signals. Monitoring of dynamic traffic is needed which is done through WSNs placed along the road which is currently being used for monitoring vehicles (ID, no. of vehicles, types) [5-6].

In Urban areas, as traffic is being managed by traffic police at signals, hospital/ ambulance en-route contact with them will give them smooth flow. The number of vehicles at the signal varies from time to time, so dynamic traffic can be analyzed by WSNs placed along the road [5-6]. So, simply assigning green light for the direction where the emergency vehicle is present is a possible solution, which in turn may complicate traffic resulting in blocks. Ambulances coming from different directions complicates it. So, to assign green light based on the condition of the patient is important. So, ambulance contact with traffic police would solve this. This is attained by below-proposed system [5].

2.1.1 Positioning System

Making certain assumptions regarding passengers in the ambulance allows us to outline the process. Driver: Drives Ambulance [5-6]; Patient: Who may/may not be critically ill; Paramedic: Person who can make judgments [28-31]. Henceforth, the nurse/paramedic is equipped with a mobile device that has functionalities of GPS (Global Positioning System) and SMS (Short Messaging Service). So, for this to work certain condition codes are to be set for every possible outcome, for example as given in the list below (which every ambulance must have) [5-7]. After the checkup, Paramedic can enter the code in the device, the message will be sent to the central database team which can grant access en-route all the way its path. (Message comprises of Condition and GPS coordinates) [1], [3-4].

Table 2

Condition Code	Description
0	Heart Attack
1	Concussion

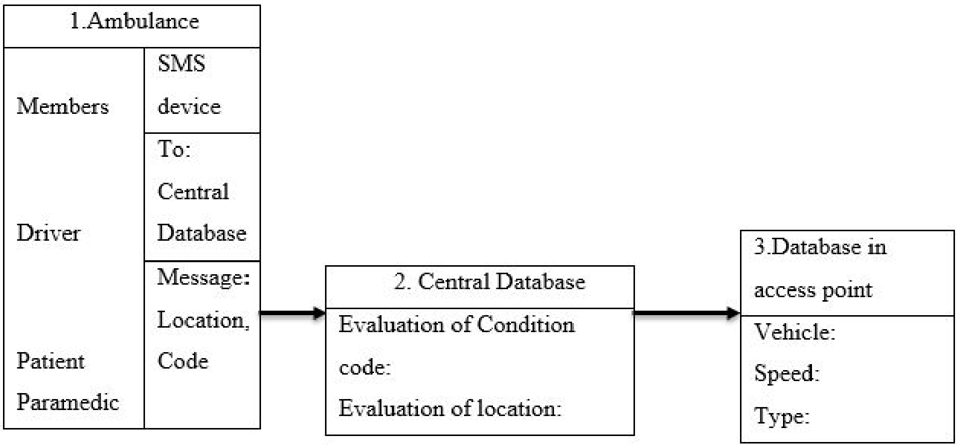

Figure 1: Parameters and Connectivity Path of an Ambulance.

The above abstract approach provides an optimized emergency vehicle management model. Certain assumptions to be made for the systematic approach. a) Left-turn is permitted all the time. b) All vehicles run at constant speed. c) Traffic volume is obtained from WSNs. [5-6]Dynamic traffic control is to be achieved in case of real-world situations by; determining queue length of traffic in each lane; Check for presence of ambulance, distance from the intersection point to ambulance; Assigning green light, and how much time to allow for each phase.

Considering all probable scenarios, the management of ambulances is done as:

Case 1: Only 1 ambulance in a lane. In this case, assign green light to the lane.

Case 2: 2 ambulances with a different priority. In this case with above SMS code technique, the ambulance with higher priority can be assigned green light. [5,29]

Case 3: 2 ambulances with the same priority in different lanes. In this case, the distance from the intersection is seen. Lane with the least distance can be allotted green light. By this approach ambulance waiting time can be reduced, thus a lesser pre-hospital time [5,7].

2.1.2 Accelerometers

Vehicle classification can be done by differentiating axles and axle spacing. An Internet of Things (IoT)Wireless sensor system, using wireless accelerometers can be used for vehicle classification and traffic volume monitoring [5,6]. Decades back, to monitor traffic density-thermocouple, the strain gauge was used. With increasing advancement in sensor technologies, in recent decades for traffic monitoring sensors were mounted under the pavement in certain depth which is prone to damage and requires costly replacement/installation [3,5]. Nowadays evolving wireless sensor helps to monitor with them mounted on road side-ways [6]. Lab tests show the feasibility of accelerometer monitor on wheel pavement-interaction. Impulse force off the vehicle induces vibration of pavement. Using MATLAB, signal smoothing is doneand output signals are developed. Peak detectors among the smooth curve in the Vertical axis (Figure 2) give the number of axles passing by. At low-optimum speeds with a margin error of 2% with lab, accelerometers can be used for real-time analysis [6].

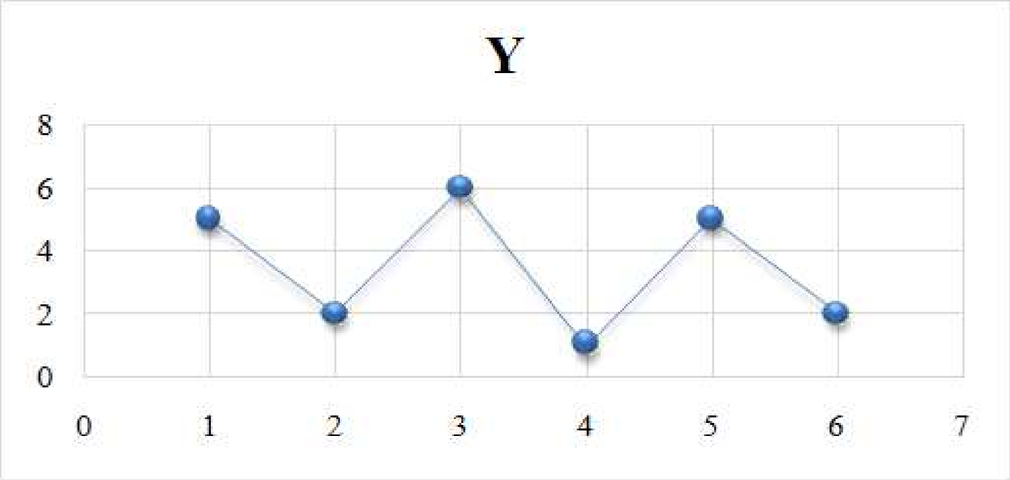

Figure 2: Output Signal Depicting Ambulance (by Axle) for High Peaks.

3. STRETCHER LOADING AND UNLOADING OPERATIONS

In general, the patient is placed on the stretcher and lifted by 2 persons (paramedic and driver) and placed in an ambulance. This involves the impact on the lower vertebrate column because of awkward postures [8]. In modern ambulances, various semi-mechanized loading systems are seen which reduces the load shared [4,12,16]. Out of the different types of loading (Easi-loader, tail-lift, ramp) based on real-time observations, video recording, posture analyzing, questionnaire, it was observed that Ramp loading under specific constraints (patient weight<75kgs) causes less force/impact on paramedic [12,13]. With patients of higher weights, a winch additional to ramp can be connected to share the load, results are shown in Table 3 below:

Table 3: Loading of Stretchers and Forces Experienced

Type of Loading	Technique	Method	Major Findings
Easi-loader	Involves Lifting of stretcher [9,11,13]	Force handle and Video recording for posture analysis	Time taken similar to the ramp system, requires more load to be applied for lifting (vertical) [12,13]
Tail-lift	Raising shoulders and involves pulling/pushing[11]	Force handle and Video recording for posture analysis	Lesser forces applied (like ramp system). Proper training required to share load [9,13,16]
Ramp (Winch) system	Involves pulling/pushing[11]	Force handle and Video recording for posture analysis	Safe for patients<75 kg.>75-Winch support can be taken but it consumes extra 20 secs [9,12,13]

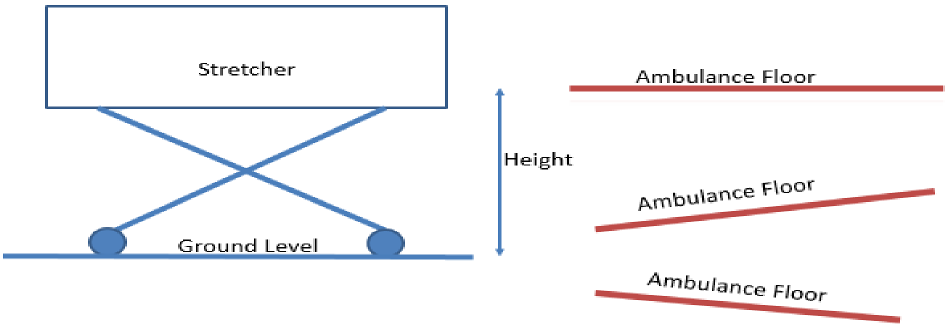

Figure 3: Depicting Lifting Height and Inclination of Ambulance Floor.

3.1 Musculoskeletal Disorder

Table 4: Statistics of the Research Work done in the Musculoskeletal Disorder Field

Method	Statistics	Risk
2012-US-Stats	20,000 registered nurses 37,000 nurse assistants	Musculoskeletal Disorder
UK ambulances-study	178 per 1000 employed-18%	Musculoskeletal Disorder-Handling Loads
Study-snapshots	Postures need correction: 24%-Non-emergency calls 56%-Emergency calls	Musculoskeletal Disorder

Table 5: Tasks Performed, and Stress Applied

Tasks Performed	Stress Applied/Effected Area	Analysis
Loading Stretcher	Shoulder, Lower Back-Musculoskeletal disorders[10,12,13,15]	Lower loading height of ambulance(lift) [12,16] appropriate angle-lower stress [15], teamwork in lifting, guidance system for easy pushing[12, 15]
In-Ambulance Tasks	Lower Vertebrate, Injuries, Mental stress[4,11]	Ergonomics, Easy reachability [9-10,16]

Table 6: Comparison of Manual and Hydraulic system for loading of stretchers

Stretcher	Peak Forces	Shoulder Flexor Moments	Time
Manual	100(Relative)[32]	100(Relative)	10 secs
Hydraulic[33]	Reduced by 13-62%[26,34]	Reduced by 16-90s%	3 times the manual

Loading/unloading of the patient to and from the ambulance is done by paramedics. It involves pushing, pulling and lifting in some cases which strain paramedic's body. Musculoskeletal disorders are more commonly seen in emergency response unit technicians these days [4,12-15]. This needs to be reduced for the efficient outcome of a paramedic. This requires a stretcher to be light in weight at the same time strong enough to handle a patient, easy way of loading with less impact on paramedic's body (lifting postures). It has been observed that the lesser the height, (Figure 3) the stretcher has to be lifted for placing in an ambulance, the lesser the forces exerted on the body [13,15].

Mechanized stretchers with hydraulic systems can be used for less impact on paramedic [32,33]. As analyzed, in the case of hydraulic stretchers convenience/force had to be traded-off with the time taken to lift [26,32-34]. Above is the table 6 showing forces and the time taken for the manual lift hydraulic systems.

4. AMBULANCE COMPARTMENT

In the current ambulance design, Paramedic treating a patient in the moving ambulance is at high risk of musculoskeletal disorders, mental stress, injuries as represented in Table 1 [7]. Major risks are observed in overexertion tasks such as push, pull, raise, hold and bodily reactions such as reach, lean, climb, etc. [14-15,18]. As reachability depends on the paramedic position with respect to patient stretcher, efforts to achieve better ergonomic design have been done in the past [19,21]. Many studies were done with respect to paramedic position in moving ambulance providing care to the patient and reaching for instruments/disposals etc. [14]

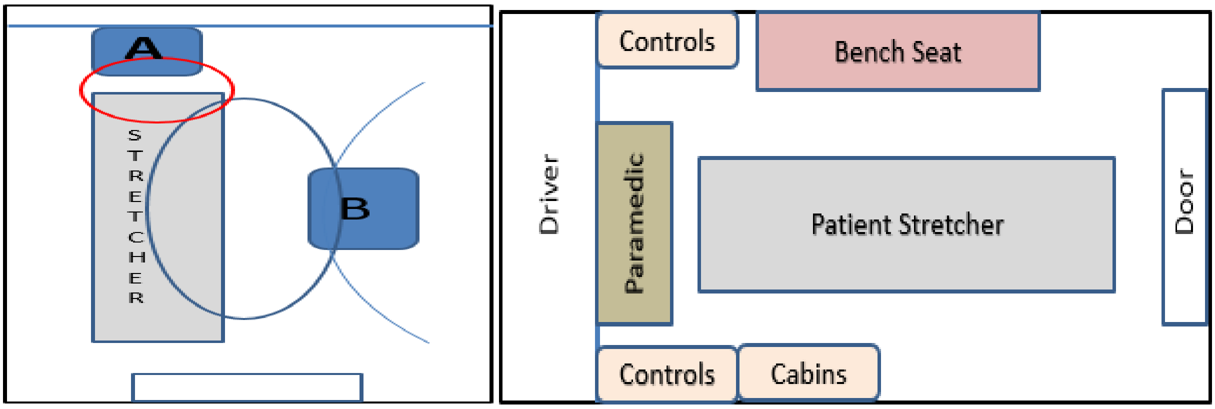

Figure 4: Paramedic Position "A and B" on the left, Ambulance Compartment Components on the Right.

In general paramedic seat is given at position A, thus designing all the equipment slots accessible to 'A' (head end of the stretcher). But while addressing the patient, paramedic prefers to sit alongside(B) of the stretcher as shown in figure 4 to perform certain tasks such as checking blood, oxygen level which makes it difficult to access equipment [4,10,11]. The paramedic had to stretch extremes for getting hold of equipment and sometimes even must leave the seat and collect it [14]. Moving around in moving ambulance proves a risk to paramedic with injuries, sudden forces exerted on the body and even fatal injuries [10]. Paramedics often come out of restraint belts to access equipment where time is of the essence and they don't buckle back immediately usually [4,17,21]. This was evaluated by the frequency of tasks performed in the study.

5. CONCLUSIONS

In case of critically injured, reaching the hospital soon allows time to treat. Urban areas see a drastic increase in Pre-hospital time in peak timings due to traffic at signals. The ambulance must be allowed through and thus reducing transport time, which is being done by using Wireless sensors technology. GPS and sensors work well hand in hand, making the traffic police know of the ambulance's whereabouts, allowing them to pass through by priority. The deadlock case has been also identified and proposed solution as suggested would be by calculating the distance from intersection/signal to the ambulance. Wireless accelerometers help in detecting vehicles with axle count which helps in vehicle classification. Thus, the pre-hospital time of the ambulance can be reduced causing a reduction in in-hospital mortalities. It was observed that paramedics do not follow the guided procedure to lift the stretcher and place it in an ambulance as time is critical at that stage. This caused paramedics to the risk of musculoskeletal disorder with the awkward postures. It was proposed that with manual stretchers, teamwork is required. Replacing manual with hydraulic/electric stretchers eases the job with no risk to paramedics but it trades-off with the time of loading and cost. It was noted that in the moving ambulance paramedic offering care to a patient on the stretcher wasn't being handled from one fixed position. Paramedic moves around the compartment for the situation apt equipment and various check-ups. Paramedic prefers to sit along the stretcher rather than at head side, hence equipment should be accessible from the other position as well. In this process, paramedic does not remain restraint all the time in the moving ambulance risking self-life. Further, recently developed lapped restraints for paramedic seating alongside stretcher inhibits the work efficiency.

CONFLICTS OF INTEREST

Authors do not have conflicts of interest.

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